(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
9 January 2003 (09.01.2003)

PCT

(10) International Publication Number
WO 03/002891 A1

(51) International Patent Classification[7]: F16H 1/28

(21) International Application Number: PCT/US02/20069

(22) International Filing Date: 24 June 2002 (24.06.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/894,665 28 June 2001 (28.06.2001) US

(63) Related by continuation (CON) or continuation-in-part (CIP) to earlier application:
US 09/894,665 (CIP)
Filed on 28 June 2001 (28.06.2001)

(71) Applicant *(for all designated States except US)*: THE TIMKEN COMPANY [US/US]; 1835 DUEBER AVENUE SW, CANTON, OH 44706 (US).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: FOX, Gerald [US/US]; 5715 OLD BRIDGE, MASSILON, OH 44706 (US).

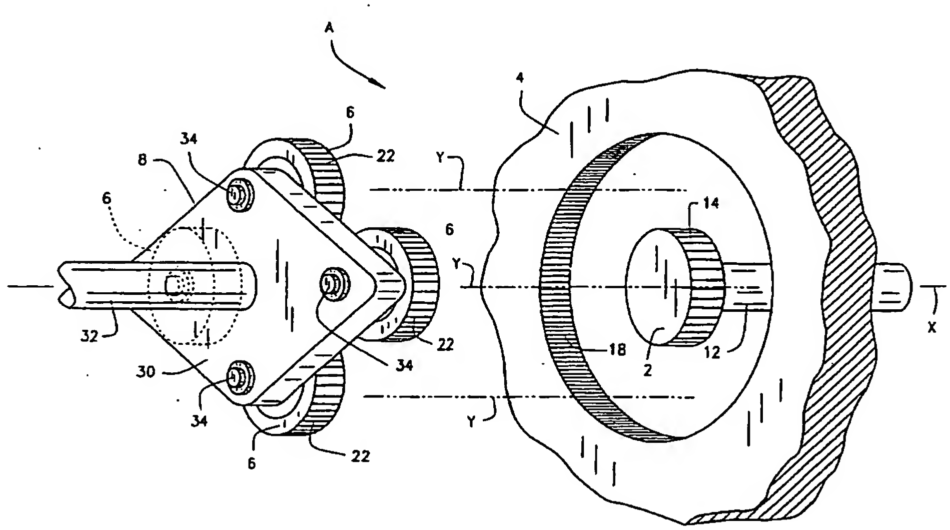
(74) Agent: BOESCHENSTEN, Edward, A.; POLSTER, LIEDER, WOODRUFF & LUCCHESI, L.C., 763 SOUTH NEW BALLAS ROAD, ST. LOUIS, MO 63141 (US).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent

[Continued on next page]

(54) Title: EPICYCLIC GEAR SYSTEM



(57) Abstract: An epicyclic gear system (A) has a sun gear (2), a ring gear (4) located around the sun gear, and planet gears (6) located between and engaged with sun and ring gears. In addition, it has a carrier (8) including a carrier flange (30) offset axially from the planet gears, carrier pins (34) projecting from the carrier flange into the planet gears, and bearings (72) between the planet gears and the carrier pins so that the planet gears rotate on the pins. Each bearing includes an inner race (46) having tapered raceways (56) presented away from the carrier pin, opposing tapered raceways (24) on the ring gear, and tapered rollers (70) organized in two rows between the raceways. Whereas the carrier pin is cantilevered from the carrier flange, the inner race is cantilevered from the carrier pin remote from the carrier flange, and this insures that the axes (Y) about which the planet gears rotate remain parallel to the central axis (X) of the system.

WO 03/002891 A1

(BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

EPICYCLIC GEAR SYSTEM

Technical Field

This invention relates in general to gear systems and, more particularly, to an epicyclic gear system.

Background Art

The typical epicyclic or planetary gear system basically has a sun gear provided with external teeth, a ring gear provided with internal teeth, and several planet gears located between the sun and ring gears and having external teeth which mesh with the teeth on the sun and ring gears. In addition to its gears, the typical system has a carrier to which the planet gears are coupled. Either the sun gear, the ring gear, or the carrier is held fast, while power is delivered to and taken from the remaining two components, and thus power is transferred through the planetary system with a change in angular velocity and an inverse change torque.

The sun and ring gears for all intents and purposes share the same axis, a central axis, while the planet gears revolve about radially offset axes that are parallel to the central axis – or at least they should be. Often the offset axes and the central axis are not parallel, and as a consequence the planet gears skew slightly between sun and ring gears. This causes excessive wear along the teeth of the planet, sun and ring gears, generates friction and heat, and renders the entire system overly noisy.

The problem certainly exists in straddle carriers. With this type of carrier the pins on which the planet gears rotate extend between two carrier flanges in which the pins are anchored at their ends. The carrier experiences torsional wind up which causes one carrier flange to rotate slightly ahead of the other flange. Not only does this skew the pin for each of the planet gears such that one end lies circumferentially ahead of the other end, but it also causes the leading end of the pin to dip toward the central axis and the other end to draw away from the central axis. The end result is a poor mesh between the planet gears and the sun and ring gears, and of course the friction, wear and noise associated with poorly meshed gears. To counteract this tendency, some planetary systems rely on gears that are wider than necessary and thus offer

greater tolerance to skewing along the gear contact. But these systems can occupy excessive space and can be quite heavy.

Other transmissions rely on a double cantilever arrangement at the pins for their planetary gears to maintain the planet gears and the sun and ring gears properly meshed. In this arrangement the carrier has a single carrier flange located beyond the ends of the planet gears, and the carrier pins project from that flange into, and indeed through, the gears. Each carrier pin has one end anchored in the carrier flange and its other end anchored in a sleeve which turns back over the pin to support the planet gear. U.S. Patent 3,303,713 to R.J. Hicks shows a double cantilevered arrangement. Often an antifriction bearing is fitted between the sleeve and the planet gear. But antifriction bearings consume space, making the planet gears excessively large in diameter, which in turn makes the entire gear system too large and heavy.

Summary of the Invention

The present invention resides in an epicyclic gear system that has a sun gear, a ring gear around the sun gear and at least one planet gear located between and engaged with the sun and ring gears. A carrier flange is offset axially from the planet gear and a carrier pin projects from it into the planet gear. An inner race is attached to the carrier pin remote from the carrier flange, and it has a raceway which is presented toward a raceway carried by the planet gear. Rolling elements are organized in a row between the opposed raceways to enable the planet gear to revolve about the carrier pin. The invention also resides in a carrier and bearing for such a gear system.

Brief Description of Drawings

Figure 1 is an exploded perspective view of an epicyclic gear system constructed in accordance with and embodying the present invention;

Figure 2 is a sectional view of the gear system at one of its planet gears and showing the coupling between the planet gear and the carrier; and

Figure 3 is a sectional view of the gear system similar to the system of Figure 2, but showing a modified coupling.

Best Mode for Carrying Out the Invention

Referring now to the drawings, a planetary transmission A (Fig. 1), which is actually an epicyclic gear system, has the capacity to transmit power of considerable magnitude, given its size and weight. In short, it has a high power density. In contrast to some planetary transmissions, the transmission A relies on meshing gears that are quite narrow, yet the teeth of those gears remain properly meshed, even when transmitting substantial power and torque. The transmission A has a central axis X of rotation about which torque is transferred to the transmission A and delivered from it. The transmission A basically includes a sun gear 2 having its axis coincident with the central axis X, a ring gear 4 which surrounds the sun gear 2 and shares the axis X with it, and planet gears 6 which mesh with and rotate between the sun and ring gears 2 and 4 about axes Y that are offset radially from, yet parallel to, the central axis X. In addition, the transmission A has a carrier 8 to which the planet gears 6 are coupled, and the carrier 8 likewise shares the central axis X.

Referring more specifically to the sun gear 2, it is attached to a shaft 12 or some other supporting structure with which it normally rotates, but it may be fixed against rotation in some installations. The sun gear 2 has external teeth 14 which are presented outwardly away from the axis X.

The ring gear 4 is typically fixed, and thus does not rotate, although it may rotate in some installations. In any event, the ring gear 4 has internal teeth 18 which are presented inwardly toward the axis X and toward the external teeth 14 on the sun gear 2 and lie concentric with them. The ring gear 4 may be part of or integrated into a housing for the transmission A.

An annular space exists between the sun and ring gears 2 and 4, and the planet gears 6 occupy that space. Each has external teeth 22 which mesh with the external teeth 14 or the sun gear 2 and the internal teeth 18 on the ring gear 4. Thus, when the sun gear 2 rotates relative to the ring gear 4 about the axis X or vice versa, the planet gears 6 will revolve, each about its offset axis Y that lies parallel to the central axis X. The planetary gears 6 are hollow, with each having two raceways 24 (Fig. 2) which taper downwardly to an intervening

surface 26 located midway between the ends of the gear 6. The large ends of the raceways 24 for each planet gear 6 open out of the ends of the gear 6.

The carrier 8 includes (Fig. 1) a carrier flange 30 to which all of the planet gears 6 are coupled, it being offset axially beyond corresponding ends on each of the gears 6. Normally, the carrier 8 rotates about the axis X, although it may remain fixed in some installations. When the carrier 8 rotates, it is usually coupled to a shaft 32 that lies along the axis X. In addition to the carrier flange 30, the carrier 8 has carrier pins 34 which project from the flange 30 into the planet gears 6, their axes generally corresponding to the axes Y of rotation for the planet gears 6.

More specifically, the carrier flange 30 opposite each planet gear 6 has a tapered hole 36 (Fig. 2). The carrier pins 34, on the other hand, have tapered surfaces 38 which lead out to threaded ends 40. The tapered surfaces 38 conform in configuration to the tapered holes 36 in the flange 30 and indeed fit snugly into the tapered holes 36 so that the pins 34 project from the face of the carrier flange 30 that is presented toward the planet gears 6. The threaded ends 40 project beyond the other face of the carrier flange 30 where they are engaged by nuts 42 which are turned down snugly against that face. This lodges the carrier pins 34 at their tapered surfaces 38 firmly in the carrier flange 30. Thus, each pin 34 is, in effect, cantilevered from the carrier flange 30.

Each carrier pin 34 projects through its planet gear 6, and at the opposite end of the gear 6, that is the end remote from the carrier flange 30, is fitted to an inner race 46 which the planet gear 6 also encircles. The inner race 46 has an end wall 48 and a sleeve 50 formed integral with the end wall 48. Indeed, the sleeve 50 turns backwardly from the end wall 48 into the interior of the gear 6 and thus encircles the carrier pin 34. The end wall contains a bore 52 into which the end of the carrier pin 34 fits with an interference fit. At its very end the carrier pin 34 is joined to the end wall 48 along a weld 54. Thus, the interference fit together with the weld 54 secure the inner race 46 firmly to the carrier pin 34. The interior surface of the sleeve 50 is somewhat larger than the carrier pin 34, and as a consequence the inner race 46 at its end wall 48 is cantilevered from the remote end of the carrier pin 34.

The sleeve 50 of the inner race 46 lies within the interior of the planet gear 6 and has two tapered raceways 56 which taper downwardly to a separating rib 58. The raceways 56, which have their centers along the axis Y, are presented outwardly away from the axis Y and toward the raceways 24 on the gear 6, each raceway 56 on the inner race 46 being opposite one of the raceways 24 on the gear 6. On the other hand, the separating rib 58 lies opposite the intervening surface 26 of the gear 6. Each raceway 56 on the inner race 46 tapers in the same direction as the raceway 24 toward which it is presented on the planet gear 6. The raceway 56 closest to the carrier flange 30 leads out to a thrust rib 60 that is formed integral with the sleeve 50 of the inner race 26. The other raceway 56 leads out to a cylindrical mounting surface 62 that surrounds the end wall 48. The mounting surface 62 has a rib ring 64 fitted to it with an interference fit and further secured with a weld 66 at its end. The rib ring 64 extends axially from the weld 66 to the large end of the tapered raceway 56, so the rib ring 64 forms another thrust rib, similar in function to the rib 60 at the end of the inner race 46 that is remote from the carrier flange 30.

The annular region between each planet gear 6 and inner race 46 that the gear 6 surrounds is occupied by rolling elements in the form of tapered rollers 70 organized into two rows. One row lies along the integral thrust rib 60 that is adjacent to the carrier flange 30 and contacts the opposed raceways 24 and 56 at that end, while the other row lies along the rib ring 64 that surrounds the end wall 48 of the inner race 46 and contacts the raceways 24 and 56 at that end. Indeed, the tapered rollers 70, which are formed from a bearing-grade steel, contact the raceways 24 and 56 along their tapered side faces, there being generally line contact here. They also bear against the thrust rib 60 and rib ring 64 at their large end faces. The thrust rib 60 and rib ring 64 prevent the rollers 70 from moving up the raceways 24 and 56 and being expelled from the annular region between the planet gear 6 and the inner race 46. The rollers 70 of each row are on apex, meaning that the conical envelopes in which the side faces of the rollers 70 of a row lie will have their apices located at a common point along the axis Y. This produces pure rolling contact between the side faces of the rollers 70 and the raceways 24 and 56. While the rollers 70 of each row may be

projects out of the flange 30. The nut 42 is turned down firmly against the carrier flange 30 to draw the tapered surface 38 of the carrier pin 34 snugly into the tapered hole 36. This secures the carrier pin 34 and inner race 46 firmly to the carrier flange 30. The remaining subassemblies 76 are installed on the carrier flange 30 in a like manner.

With the carrier 8 so assembled, it is installed over the sun gear 2 and into the ring gear 4 such that the external teeth 22 on the planet gears 6 engage the external teeth 14 in the sun gear 2 and the internal teeth 18 on the ring gear 4.

When torque is applied to the shaft 12 to rotate the sun gear 2, the planet gears 6 revolve and move along the ring gear 4, thus imparting rotation to the carrier 8 and the shaft 32 extended from it. The angular velocities of the two shafts 12 and 32 differ and with that difference a change in the torque ensues. Of course, the torque may be applied to the shaft 32 and taken from the shaft 12. Actually, any one of the sun gear 2, ring gear 4 and carrier 8 may be held fast and torque delivered to and taken from the remaining two components.

In a modified subassembly 78 (Fig. 3) the carrier pin 34 is formed integral with the inner race 46.

The cantilever of the carrier pins 34 from the carrier flange 30 and the cantilever of the inner races 46 from the carrier pins 34, that is the so-called "double cantilever", insures that the axes Y of rotation for the ring gears 6 remain parallel to the center axis X. As a consequence, the ring gears 6 do not require excessive width to resist skewing. The inner races 46, being mounted directly on the carrier pins 34, instead of on intervening components, together with the integration of the outer raceways 24 into the planet gears 6, enables the bearings 72 to be of a diameter that is smaller than the diameters of bearings in more conventional epicyclic gear systems. This, in turn, can permit use of smaller sun and ring gears 2 and 4, and otherwise render the entire transmission highly compact and light in weight.

In lieu of a double row tapered roller bearing 70, each planet gear 6 may be coupled to its carrier pin 34 on the carrier 8 with a double row angular contact ball bearing or even with a cylindrical or spherical roller bearing. Also,

more or less than four planet gears 6 may be used between the sun gear 2 and ring gear 4.

Claims:

1. An epicyclic gear system comprising: a sun gear located along a central axis; a ring gear located around the sun gear and sharing the central axis with the sun gear; at least one planet gear located between and engaged with the sun and ring gears for rotation about an offset axis, the planet gear having a raceway that is presented toward the offset axis; and a carrier coupled to the planet gear and including a carrier flange, a carrier pin projecting from the flange into the planet gear, an inner race attached to the carrier pin remote from the carrier flange and also located within the ring gear where it has a raceway presented outwardly away from the offset axis and toward the raceway carried by the ring gear; and rolling elements located in a row between and contacting the raceways on the ring gear and inner race.

2. A gear system according to claim 1 wherein the carrier pin is cantilevered from the carrier flange, and the inner race is cantilevered from the carrier pin at a location remote from the carrier flange.

3. A gear system according to claim 2 wherein the inner race includes a sleeve which surrounds, but is spaced from the carrier pin, and an end wall connected to the sleeve at one end of the sleeve; wherein the raceway for the inner race is on the sleeve; and wherein the carrier pin is connected to the inner race at the end wall of the inner race.

4. A gear system according to claim 3 wherein the end wall and the sleeve are formed integral.

5. A gear system according to claim 4 wherein the carrier pin and the end wall of the inner race are formed integral.

6. A gear system according to claim 3 wherein the raceway on the planet gear is one of two outer raceways which are located oblique to the offset axis and are inclined in opposite directions; wherein the raceway on the inner race is one of two inner raceways that are oriented oblique to the offset axis and inclined in opposite directions, one of the inner raceways being located within and inclined in the same direction as one of the outer raceways and the other inner raceway being located within and inclined in the same direction as the

other outer raceway; and wherein the rolling elements are arranged in two rows between the outer and inner raceways.

7. A gear system according to claim 6 wherein the raceways are tapered; wherein the rolling elements are tapered rollers; wherein the sleeve of the inner race has thrust ribs at the large ends of the tapered inner raceways; and wherein one of the thrust ribs fits over the inner race as an initially separate component.

8. In an epicyclic gear system including a sun gear located along a central axis, a ring gear located around the sun gear and sharing the central axis; planet gears located between and engaged with the sun and ring gears for rotation about offset axes that are located around the central axis; a carrier coupled with the planet gears and including a carrier flange offset axially from the planet gears, carrier pins cantilevered from the carrier flange and projected into the planet gears along the offset axes, there being a separate carrier pin for each planet gear, an inner race cantilevered from each carrier pin remote from the carrier flange and located within the planet gear into which the pin projects, a first inner raceway carried by each inner race and presented outwardly away from the offset axes for that inner race, a first outer raceway carried by the planet gear that is located around the carrier pin and presented inwardly toward the offset axes and toward the first inner raceway on the inner race; and rolling elements located between and contacting the first raceways.

9. The combination according to claim 8 and further comprising a second inner raceway carried by the inner race around each carrier pin and presented outwardly away from the offset axes for that carrier pin, a second outer raceway carried by the planet gear that is around the carrier pin and presented inwardly toward the offset axes and the second inner raceway; and wherein the rolling elements are arranged in two rows, with one row being between the first inner and outer raceways and the other row being between the second inner and outer raceways.

10. The combination according to claim 9 wherein the raceways are oblique to the offset axes; and wherein the first inner and outer raceways are inclined in the same direction and the second inner and outer raceways are

inclined in the same direction, which direction is opposite to the direction of inclination of the first raceways, whereby the rolling elements in the row between the first raceways will transfer thrust loads in one axial direction and the rolling elements in the row between the second raceways will transfer thrust loads in the opposite axial direction.

11. The combination according to claim 10 wherein the raceways are tapered and the rolling elements are tapered rollers.

12. The combination according to claim 11 wherein the first and second raceways taper inwardly toward each other so that the large ends of the rollers in the row between the first raceways are presented away from the large ends of the rollers in the row between the second raceways.

13. The combination according to claim 12 wherein the inner race has thrust ribs at the large ends of the inner raceways; and wherein one of the thrust ribs is a rib ring formed as a separate component that is installed on the inner race after the rollers are placed between the planet gear and the inner race.

14. The combination according to claim 10 wherein inner race includes a sleeve on which the inner raceways are located and an end wall at one end of the sleeve; the end wall being attached firmly to the carrier pin remote from the carrier flange with the sleeve surrounding, but being spaced from, the carrier pin.

15. In an epicyclic gear system having a central axis and a planet gear that rotates about an offset axis that is offset radially from the central axis, the improvement comprising: a carrier flange located beyond one end of the planet gear, a carrier pin projecting from the carrier flange into the planet gear such that it is cantilevered from the carrier flange; and a bearing located between the carrier pin and the planet gear for coupling the planet gear to the carrier flange and enabling the planet gear to rotate about the offset axis, the bearing including an inner race which is attached to the carrier pin remote from the carrier flange and includes a sleeve which surrounds the carrier pin, yet is spaced from the pin, the sleeve having a first raceway that is presented outwardly away from the offset axis for the planet gear, the bearing also including a first outer raceway that is carried by the planet gear and is presented

inwardly toward the offset axis and the first inner raceway, the bearing further including rolling elements arranged in a row between the first inner and outer raceways.

16. The combination according to claim 15 wherein the inner race also includes an end wall extended between the sleeve and the carrier pin and attached firmly to the pin remote from the carrier, whereby the inner race is cantilevered from the carrier pin.

17. The combination according to claim 15 wherein the first inner and outer raceways are inclined in the same direction with respect to the offset axis; wherein the inner race has a second inner raceway that is presented outwardly away from the offset axis and is inclined with respect to the offset axis in a direction opposite the inclination of the first raceways, and the bearing also includes a second outer raceway carried by the planet gear and presented inwardly toward the second inner raceway and inclined with respect to the offset axis in the same direction as the second inner raceway; and wherein the rolling elements are organized in first and second rows, the rolling elements of the first row being between the first raceways and the rolling elements of the second row being between the second raceways.

18. The combination according to claim 17 wherein the raceways are tapered and the rolling elements are tapered rollers; wherein the inner race has a thrust rib at the large end of the first inner raceway with the rib projecting beyond the first inner raceway, the large ends of the rollers in the first row being against the thrust rib, and the inner race also has a mounting surface at the large end of the second inner raceway with the mounting surface having a diameter no greater than the diameter of the large end of the second inner raceway, and wherein an initially separate rib ring is located around the mounting surface on the inner race and projects outwardly beyond the large end of the second inner raceway, the large ends of the tapered rollers in the second row being against the rib ring.

19. The combination according to claim 18 wherein the inner race also includes an end wall extended between the sleeve and the carrier pin and

attached firmly to the carrier pin remote from the carrier flange, whereby the inner race is cantilevered from the carrier pin.

20. The combination according to claim 19 wherein the end wall and sleeve of the inner race are integral.

21. In an epicyclic gear system having a central axis and a planet gear offset radially from the central axis where it is located between and engaged with other gears, the improvement comprising: a carrier flange located beyond one end of the planet gear; a carrier pin projecting from the carrier flange into the planet gear, the carrier pin being offset from the central axis and cantilevered from the carrier flange; an inner race attached to the pin remote from the carrier flange such that the inner race is cantilevered from the pin, the inner race having an inner raceway that is presented outwardly away from the carrier pin; an outer raceway carried by the planet gear and presented toward the inner raceway on the inner race; and rolling elements located in a row between and contacting the inner and outer raceways.

22. The combination according to claim 21 wherein the inner race includes a sleeve which surrounds the carrier pin and carries the inner raceway, yet is spaced from the pin, and an end wall at one end of the sleeve, with the inner race being attached to the carrier pin at the end wall.

23. An epicyclic gear system according to claim 1 wherein at least some of the rolling elements are covered with a tribological coating capable of retarding metal adhesion.

24. An epicyclic gear system according to claim 8 wherein at least some of the rolling elements are covered with a tribological coating capable of retarding metal adhesion.

25. An epicyclic gear system according to claim 15 wherein at least some of the rolling elements are covered with a tribological coating capable of retarding metal adhesion.

26. An epicyclic gear system according to claim 21 wherein at least some of the rolling elements are covered with a tribological coating capable of retarding metal adhesion.

27. An epicyclic gear system according to claim 7 wherein the tapered rollers have tapered side faces along which they contact the inner and outer raceways; and wherein at least every other roller in each row, along its tapered side face, is covered with a tribological coating capable of retarding metal adhesion.

28. The combination according to claim 13 wherein the tapered rollers have tapered side faces along which they contact the inner and outer raceways; and wherein at least every other roller in each row, along its tapered side face, is covered with a tribological coating capable of retarding metal adhesion.

29. The combination according to claim 18 wherein the tapered rollers have tapered side faces along which they contact the inner and outer raceways; and wherein at least every other roller in each row, along its tapered side face, is covered with a tribological coating capable of retarding metal adhesion.

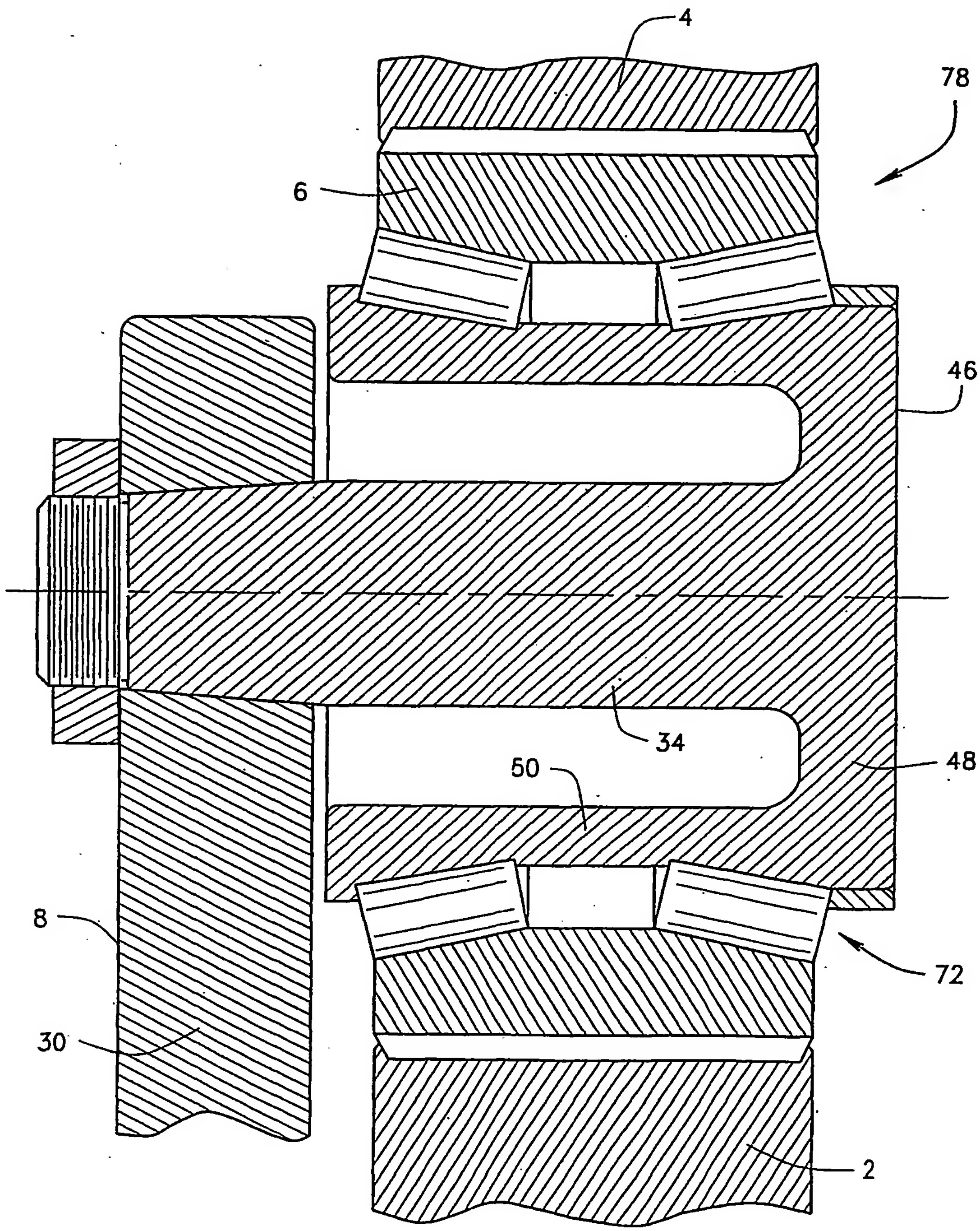


FIG. 3

INTERNATIONAL SEARCH REPORT

Internati[onal Ap]plication No
PCT/US 02/20069

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F16H1/28

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F16H F16C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 3 964 334 A (HICKS RAYMOND JOHN) 22 June 1976 (1976-06-22) abstract; figures	1,8,15, 21
A	US 3 303 713 A (HICKS RAYMOND J) 14 February 1967 (1967-02-14) cited in the application abstract; figures	1,8,15, 21
A	EP 0 054 280 A (HOHENZOLLERN HUETTENVERWALT) 23 June 1982 (1982-06-23) abstract; figures	1,8,15, 21
A	DE 682 354 C (WERKE KIEL AKT GES DEUTSCHE) 13 October 1939 (1939-10-13) abstract; figures	1,8,15, 21

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 October 2002	21/10/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Wagner, H

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 02/20069

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 24 42 588 A (KLOECKNER HUMBOLDT DEUTZ AG) 18 March 1976 (1976-03-18) abstract; figures	1,8,15, 21
A	DE 197 06 686 A (TAUSEND ERICH) 27 August 1998 (1998-08-27) abstract; figures	1,8,15, 21

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 02/20069

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 3964334	A	22-06-1976	GB	1456085 A	17-11-1976
			CA	1007898 A1	05-04-1977
			DE	2517022 A1	06-11-1975
			FR	2268201 A1	14-11-1975
			JP	50139252 A	07-11-1975
US 3303713	A	14-02-1967	GB	1101131 A	31-01-1968
			DE	1500451 A1	08-05-1969
EP 0054280	A	23-06-1982	DE	3046934 A1	15-07-1982
			AT	12006 T	15-03-1985
			DE	3169153 D1	04-04-1985
			EP	0054280 A1	23-06-1982
DE 682354	C	13-10-1939	NONE		
DE 2442588	A	18-03-1976	DE	2442588 A1	18-03-1976
DE 19706686	A	27-08-1998	DE	19706686 A1	27-08-1998